US009264498B2

(12) **United States Patent**
**Das et al.**

(10) **Patent No.: US 9,264,498 B2**
(45) **Date of Patent: Feb. 16, 2016**

(54) **METHODS AND APPARATUS FOR CREATION, ADVERTISEMENT, AND DISCOVERY OF PEER-TO-PEER OVERLAY NETWORKS**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 882 days.

(21) Appl. No.: **12/720,597**

(22) Filed: **Mar. 9, 2010**

(65) **Prior Publication Data**

US 2010/0312622 A1 Dec. 9, 2010

**Related U.S. Application Data**

(60) Provisional application No. 61/159,387, filed on Mar. 11, 2009, provisional application No. 61/185,110, filed on Jun. 8, 2009.

(51) **Int. Cl.**
***G06F 15/16*** (2006.01)
***H04L 29/08*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H04L 67/16*** (2013.01); ***G06Q 30/0241*** (2013.01); ***H04L 29/06*** (2013.01); ***H04L 29/12113*** (2013.01); ***H04L 61/1541*** (2013.01); ***H04L 67/104*** (2013.01); ***H04L 67/1046*** (2013.01)

(58) **Field of Classification Search**
USPC ..... 709/200–236, 250; 370/231–245, 370/351–409
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,401,132 B1 * 7/2008 Krumel et al. ..... 709/220
2003/0002521 A1 * 1/2003 Traversat et al. ..... 370/465

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1848817 A 10/2006
EP 08290626 * 6/2008 ..... H04L 12/56
TW I276328 B 3/2007

OTHER PUBLICATIONS

Lua et al., 'A survey and comparison of peer-to-peer overlay network schemes', IEEE communication, 2nd Quarter, 2005.*
International Search Report and Written Opinion—PCT/US2010/027053, International Search Authority—European Patent Office—Jun. 10, 2010.

(Continued)

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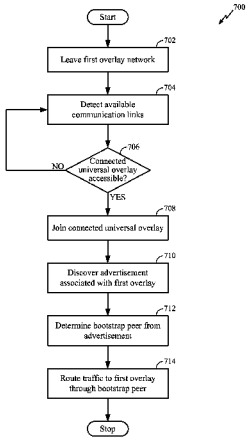
(74) *Attorney, Agent, or Firm* — Paul Kuo

(57) **ABSTRACT**

Methods and apparatus for creation, advertisement, and discovery of peer-to-peer overlay networks. A method includes detecting one or more communication links that allow a node to communicate with other nodes, determining that a universal overlay network is accessible using at least one communication link, selecting a selected communication link from the at least one communication link, and joining the universal overlay network using the selected communication link. An apparatus includes a transceiver configured to detect one or more communication links that allow a node to communicate with other nodes, and a processor configured to determine that a universal overlay network is accessible using at least one communication link, select a selected communication link from the at least one communication link, and join the universal overlay network using the selected communication link.

**36 Claims, 8 Drawing Sheets**



(51) **Int. Cl.**

| | |
|---|---|
| ***H04L 29/06*** | (2006.01) |
| ***G06Q 30/02*** | (2012.01) |
| ***H04L 29/12*** | (2006.01) |
| *G06F 12/00* | (2006.01) |

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 2003/0187973 | A1* | 10/2003 | Wesley | 709/224 |
| 2004/0246911 | A1* | 12/2004 | Bonsma et al. | 370/254 |
| 2010/0064049 | A1* | 3/2010 | Magharei et al. | 709/229 |

OTHER PUBLICATIONS

Paul Francis: "Yoid: Extending the Internet Multicast Architecture" ACIRI Apr. 2, 2000, pp. 1-39, XP002583585 Retrieved from the Internet: URL:http://wvvw.i cir.org/yoi d/docs/ycHtmlL/htmlRoot.html> [retrieved on May 25, 2010] paragraph [01.4] p. 2.1.

Ratnasamy S., et al., "A Scalable Content-Addressable Network" Computer Communication Review, ACM, New A29York, NY, US LNKD-DOI:10.1145/964723.383072, vol. 31, No. 4, Oct. 1, 2001, pp. 161-172, XP001115754 ISSN: 0146-4833 paragraph [0001]—paragraph [02.2].

Taiwan Search Report—TW099107161—TIPO—Apr. 1, 2013.

* cited by examiner

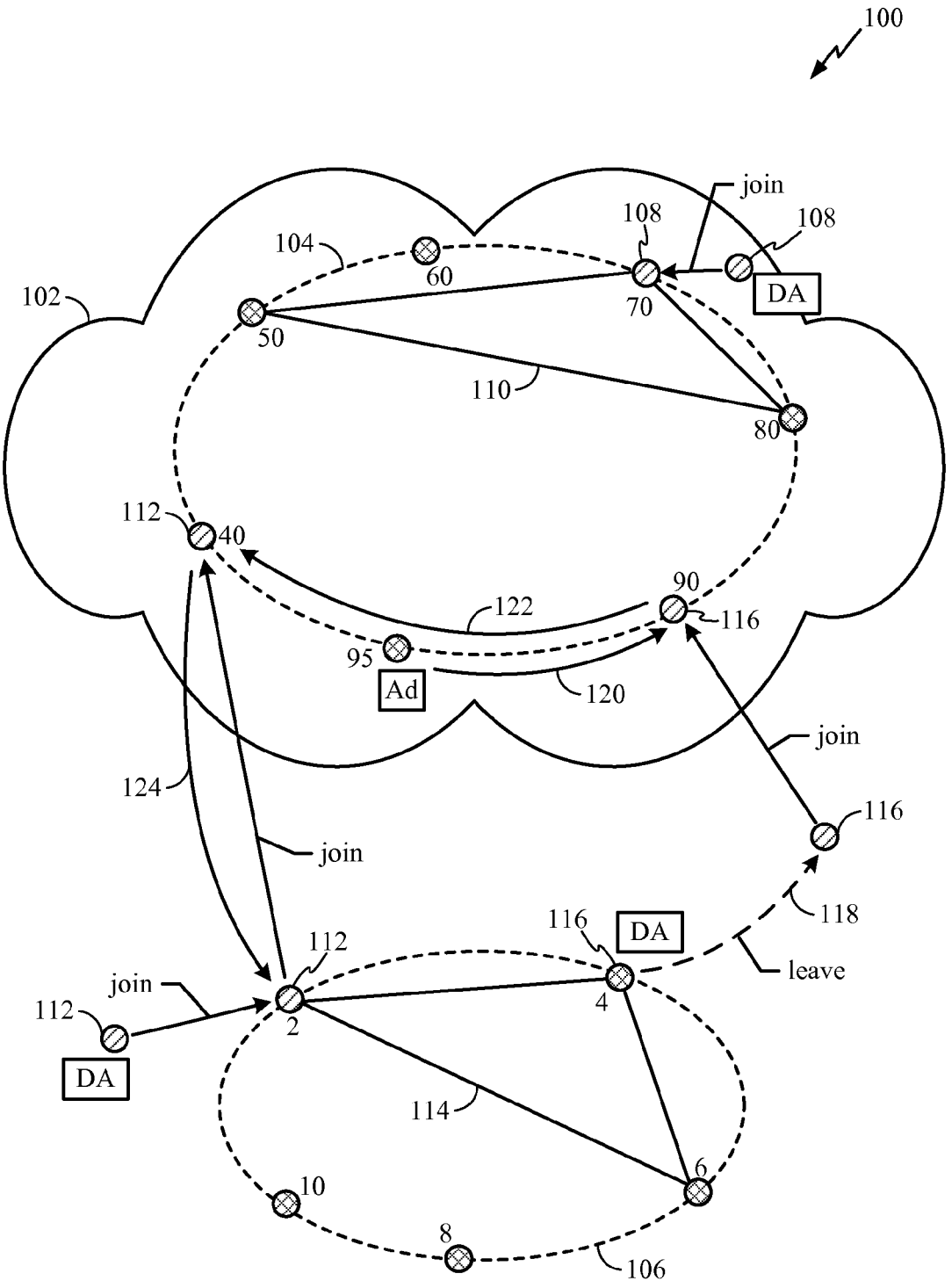

100
102
104
60
108
108
join
DA
70
50
110
80
112
40
90
122
116
95
Ad
120
join
124
116
join
118
116
DA
leave
112
join
112
DA
2
4
114
6
10
8
106

FIG. 1

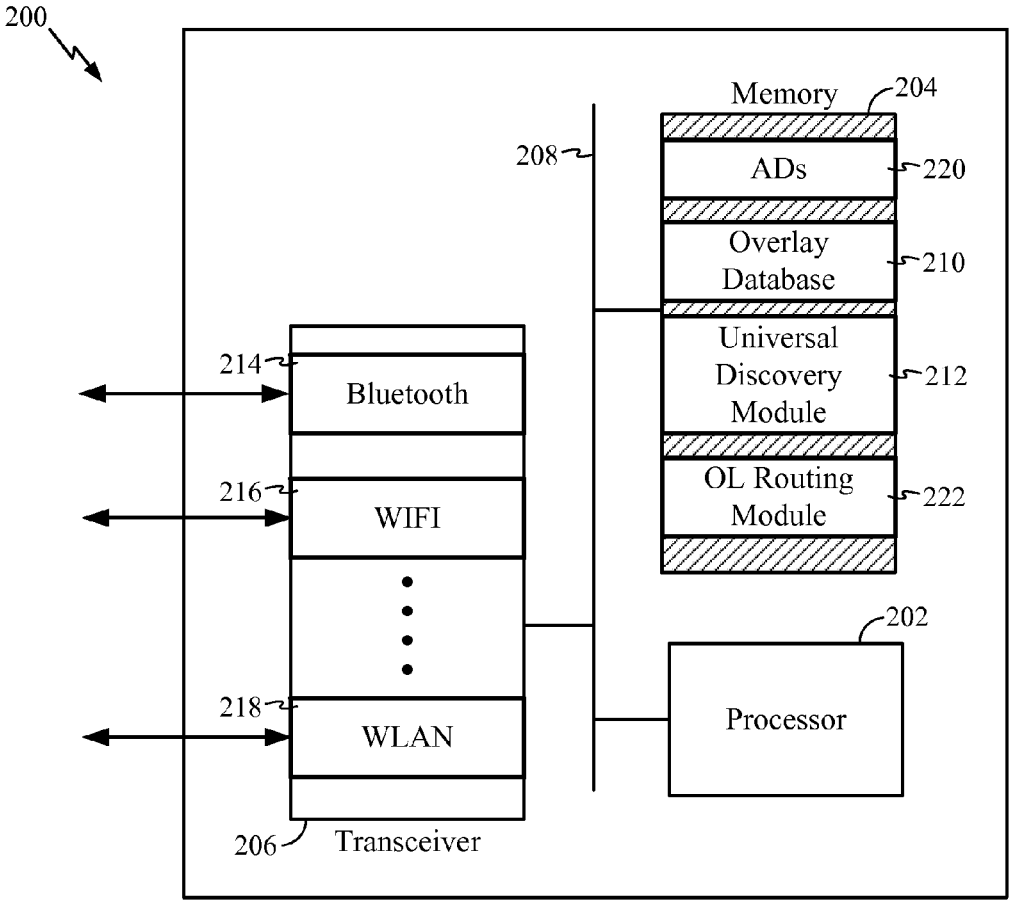

200
Memory
204
208
ADs
220
Overlay Database
210
Universal Discovery Module
212
OL Routing Module
222
214
Bluetooth
216
WIFI
218
WLAN
202
Processor
206
Transceiver

FIG. 2

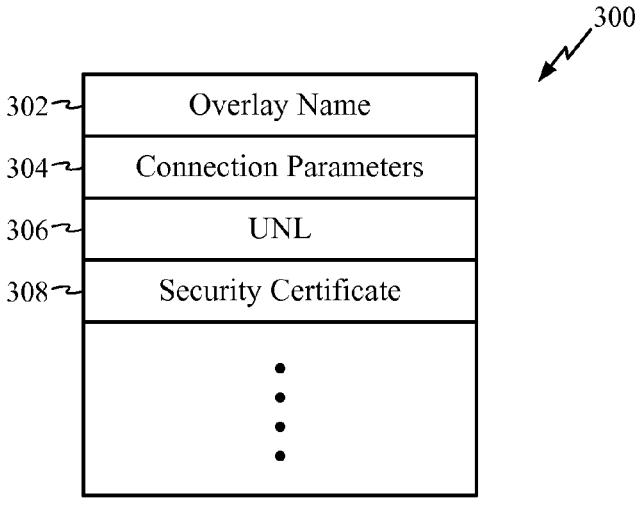
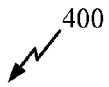

300
302
Overlay Name
304
Connection Parameters
306
UNL
308
Security Certificate

FIG. 3




| 402 Interface Type | 404 Network Identifier | 406 Status |
|---|---|---|
| WWAN | Universal Connected | joined |
| | Universal Disconnected | -- |
| | Sports Clips | joined |
| | -- | |
| WiFi | Universal Connected | -- |
| | Universal Disconnected | joined |
| | Photo Share | joined |
| | Music Share | -- |
| | -- | |
| | -- | |
| BlueTooth | Universal Connected | -- |
| | Universal Disconnected | -- |
| | Music Share | joined |
| | -- | -- |
| | -- | -- |
| | -- | -- |

FIG. 4

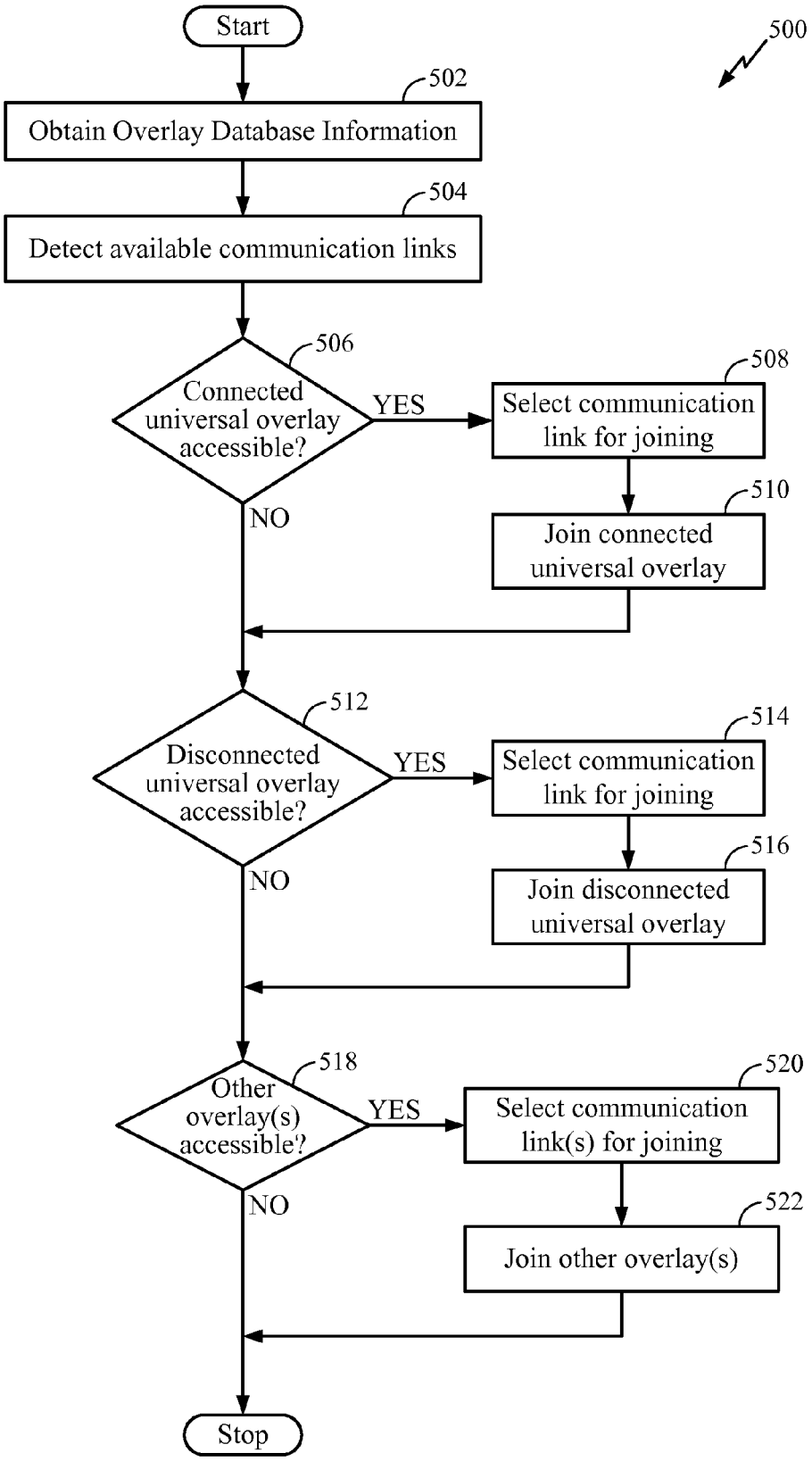

Start
500
502
Obtain Overlay Database Information
504
Detect available communication links
506
Connected universal overlay accessible?
YES
508
Select communication link for joining
NO
510
Join connected universal overlay
512
Disconnected universal overlay accessible?
YES
514
Select communication link for joining
NO
516
Join disconnected universal overlay
518
Other overlay(s) accessible?
YES
520
Select communication link(s) for joining
NO
522
Join other overlay(s)
Stop

FIG. 5

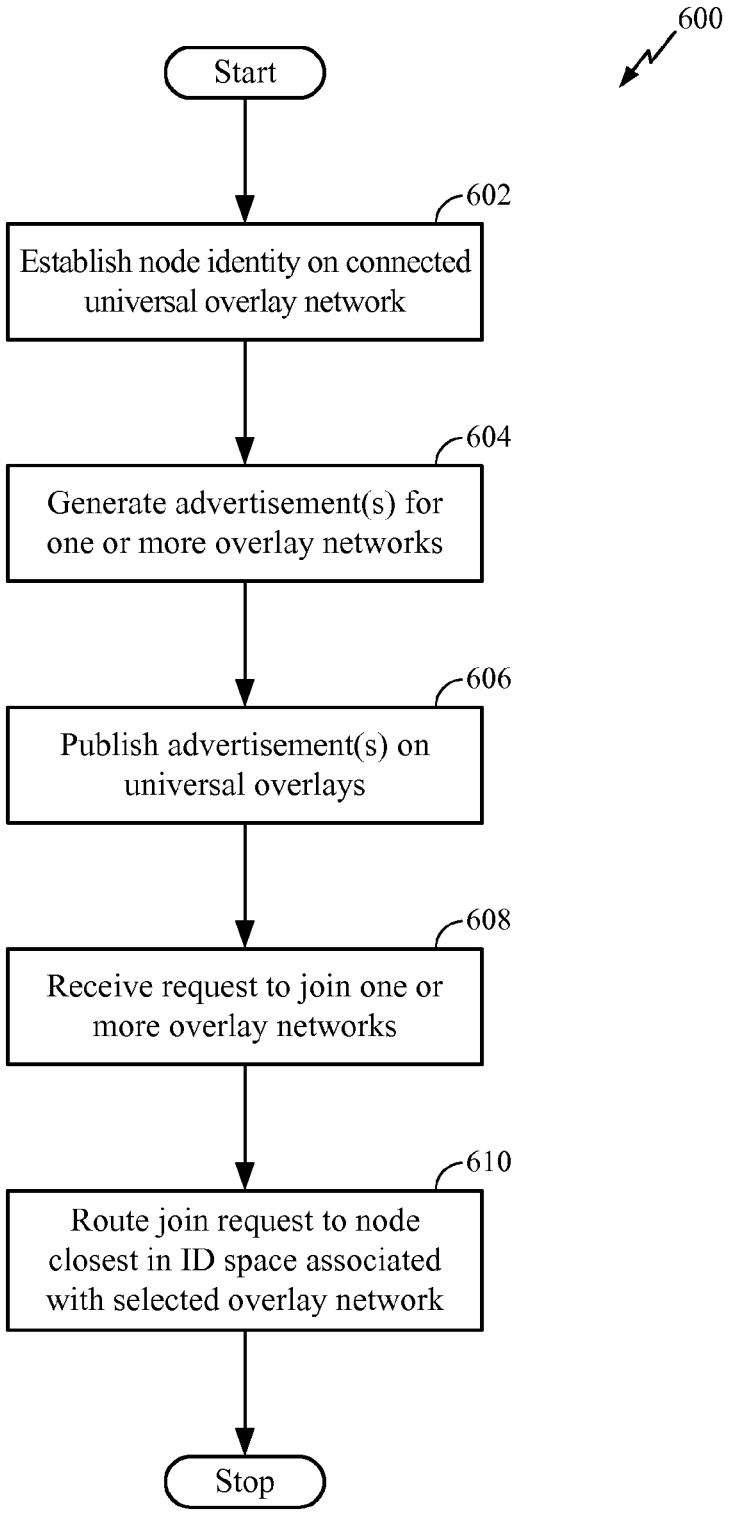

600
Start
602
Establish node identity on connected universal overlay network
604
Generate advertisement(s) for one or more overlay networks
606
Publish advertisement(s) on universal overlays
608
Receive request to join one or more overlay networks
610
Route join request to node closest in ID space associated with selected overlay network
Stop

FIG. 6

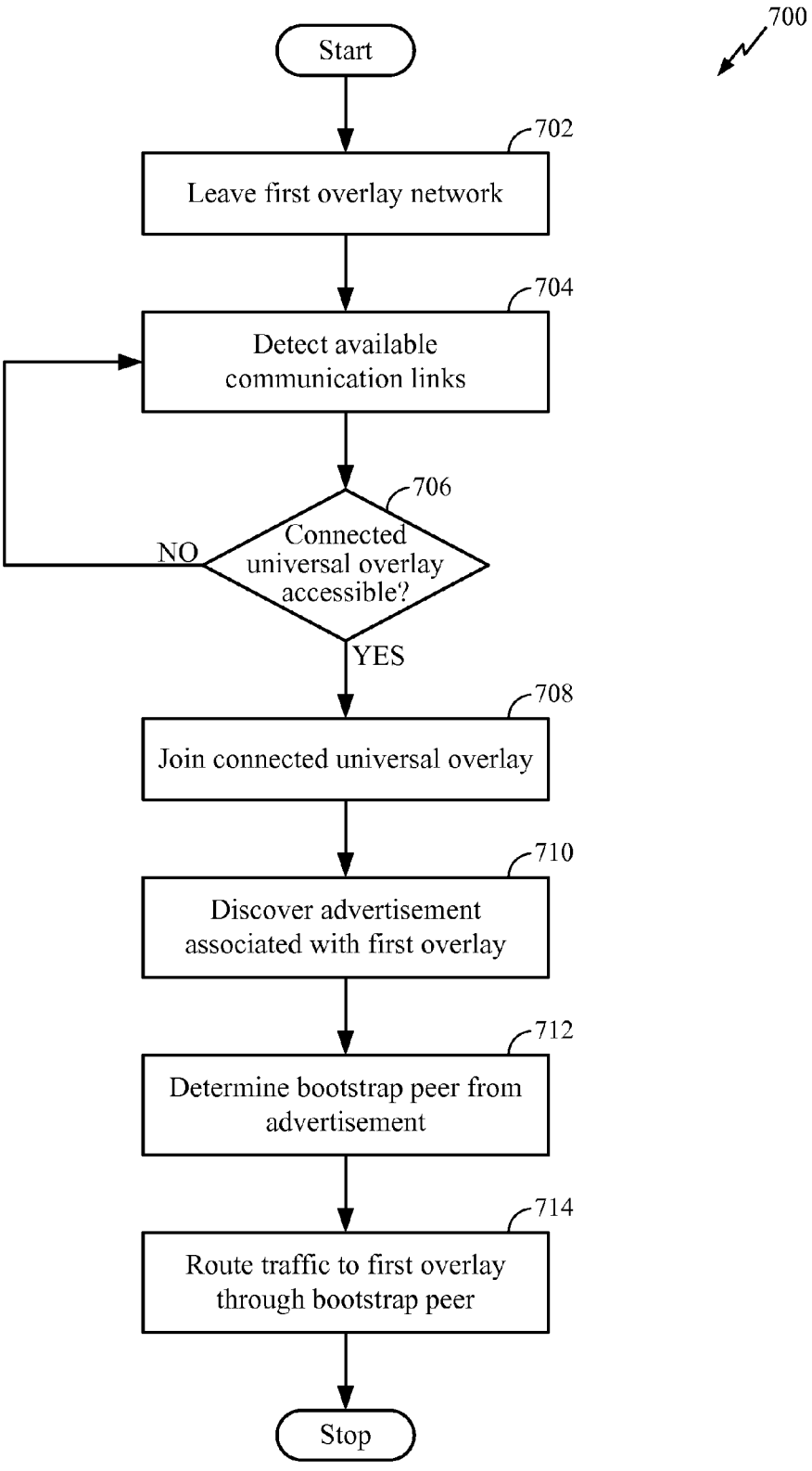

700
Start
702
Leave first overlay network
704
Detect available communication links
706
Connected universal overlay accessible?
NO
YES
708
Join connected universal overlay
710
Discover advertisement associated with first overlay
712
Determine bootstrap peer from advertisement
714
Route traffic to first overlay through bootstrap peer
Stop

FIG. 7

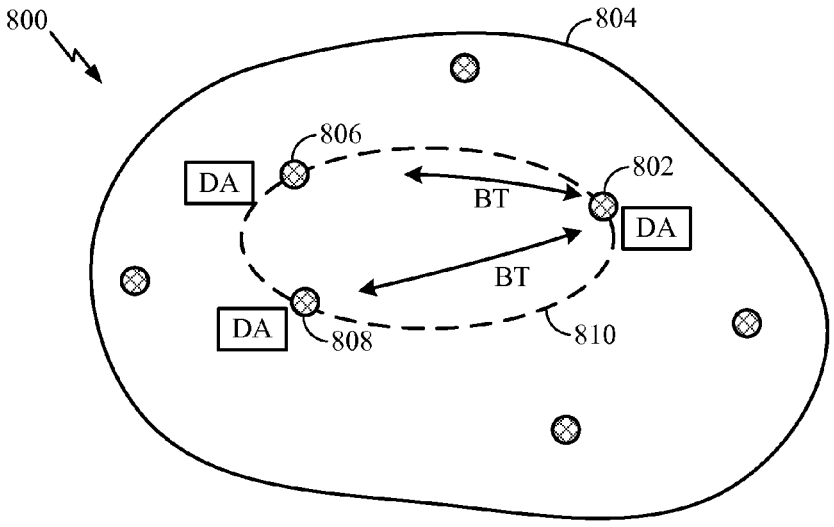

800
804
806
DA
802
BT
DA
BT
DA
808
810

FIG. 8

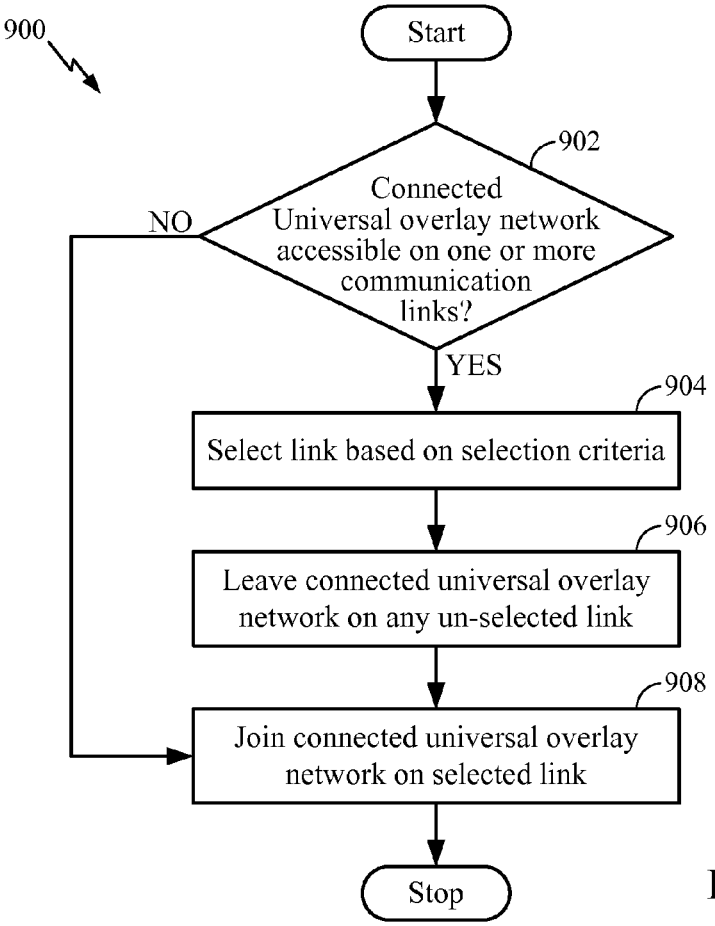

900
Start
902
Connected Universal overlay network accessible on one or more communication links?
NO
YES
904
Select link based on selection criteria
906
Leave connected universal overlay network on any un-selected link
908
Join connected universal overlay network on selected link
Stop

FIG. 9

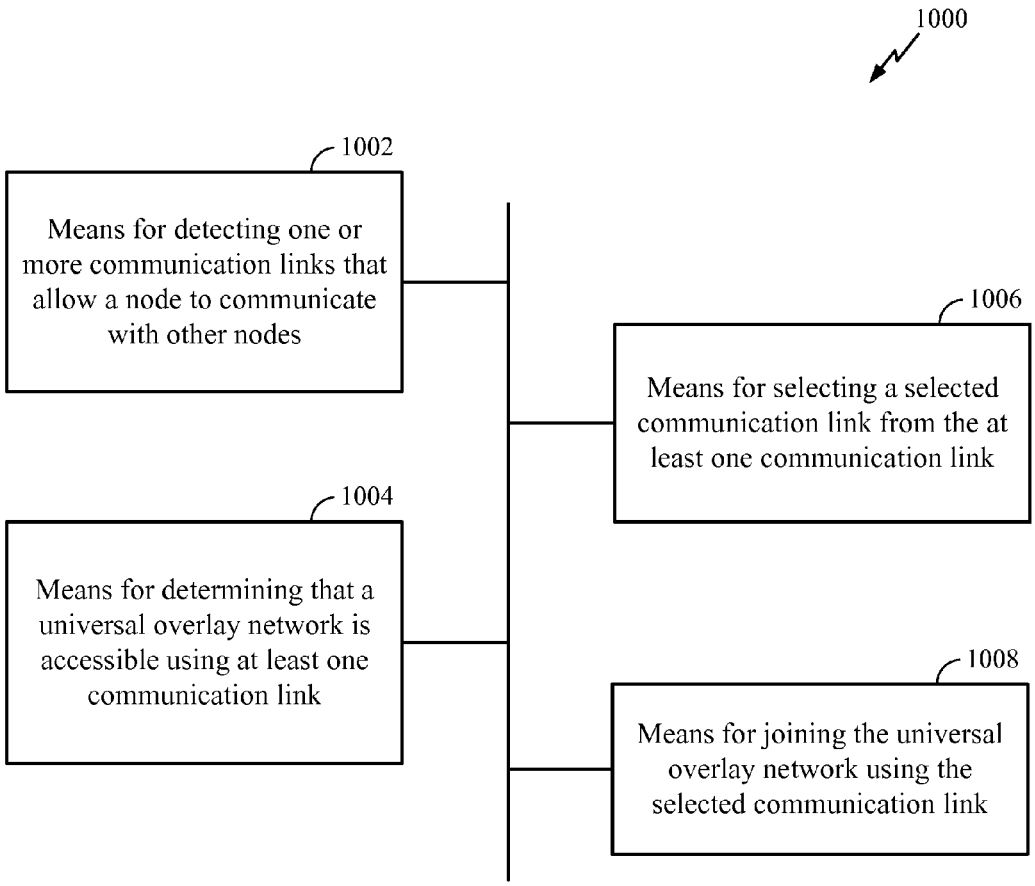

1000
1002
Means for detecting one or more communication links that allow a node to communicate with other nodes
1004
Means for determining that a universal overlay network is accessible using at least one communication link
1006
Means for selecting a selected communication link from the at least one communication link
1008
Means for joining the universal overlay network using the selected communication link

FIG. 10

# METHODS AND APPARATUS FOR CREATION, ADVERTISEMENT, AND DISCOVERY OF PEER-TO-PEER OVERLAY NETWORKS

## CLAIM OF PRIORITY UNDER 35 U.S.C. §119

The present Application for Patent claims priority to Provisional Application No. 61/159,387 entitled "Methods and Apparatus for Creation, Advertisement and Discovery of Peer To Peer Overlay Networks" filed Mar. 11, 2009, and assigned to the assignee hereof and hereby expressly incorporated by reference herein.

The present Application for Patent also claims priority to Provisional Application No. 61/185,110 entitled "Methods and Apparatus for Creation, Advertisement, and Discovery of Peer To Peer Overlay Networks" filed Jun. 8, 2009, and assigned to the assignee hereof and hereby expressly incorporated by reference herein.

## BACKGROUND

1. Field

The present application relates generally to the operation of overlay networks, and more particularly, to methods and apparatus for creation, advertisement, and discovery of peer-to-peer overlay networks.

2. Background

A network in which member nodes obtain services in the absence of server-based infrastructure is referred to as a "peer-to-peer" overlay network. In a peer-to-peer overlay, peer nodes co-operate with each other both to provide services and to maintain the network. Peer-to-peer overlay networks can be built on top of one or more underlying networks, such as networks utilizing the Internet Protocol (IP).

An overlay network is typically formed after an overlay advertisement is made on a medium that is common to multiple nodes, such as the Internet. However, access to the Internet to bring together overlay advertisers and nodes interested in joining the overlay network may not always exist. This situation may be problematic because even though Internet access may not be available there may still be a need to advertise and form overlay networks. For example, two nodes may individually use link local broadcast to attempt to create an overlay network. However this can result in a first set of nodes joining a first overlay network advertised by one of the nodes and a second set of nodes joining a second overlay network advertised by the other node. This results in concurrent overlay creation that can cause islands of connectivity. This situation can also occur if the interfaces used by the nodes to advertise the overlay networks are different.

Even if the Internet is available, it may be difficult for nodes to join an advertised overlay network. For example, nodes that have decided to join an overlay network need to learn how to reach bootstrap peers that control the joining process. Typically, bootstrap peers are required to have globally routable addresses and it may be difficult for a node to reach these bootstrap peers.

Thus, there are two challenges associated with overlay network creation, advertisement, and discovery. The first challenge is how to reduce the chance of concurrent overlay creation that can cause islands of connectivity. The second challenge is to make joining an overlay network more general and useful, and to do that, bootstrap peer reachability needs to be simplified.

One approach for solving overlay network discovery problems uses a domain name service (DNS) infrastructure to advertise overlay networks. For example, each node uses a dynamic DNS-like infrastructure to advertise overlay networks. Unfortunately, this technique is inefficient and makes it difficult for a node to discover and join a particular overlay network. For example, this approach does not address the problem of concurrent overlay network creation since it assumes Internet access is always available to advertise or discover overlays. Furthermore, discovery is an even harder problem since implementing a search over the DNS infrastructure does not scale.

Therefore, it would be desirable to have a simple cost effective mechanism that operates to facilitate the creation, advertisement, and discovery of peer-to-peer overlay networks.



## SUMMARY

In one or more aspects, a universal discovery system, comprising methods and apparatus, is provided that operates to facilitate the creation, advertisement, and discovery of peer-to-peer overlay networks. In various implementations of the universal discovery system, all nodes attempt to become part of identifiable overlay networks based on the communication mediums that are accessible. Furthermore, each node attempts to become part of a universal overlay at all times. Once part of the universal overlay network, published overlay network advertisements facilitate easy connectivity to bootstrap peers using universal node locators (UNLs).

In an aspect, a method is provided for operating a node to discover a peer-to-peer overlay network. The method comprises detecting one or more communication links that allow the node to communicate with other nodes, determining that a universal overlay network is accessible using at least one communication link, selecting a selected communication link from the at least one communication link, and joining the universal overlay network using the selected communication link.

In an aspect, an apparatus is provided for discovering peer-to-peer overlay networks. The apparatus comprises a transceiver configured to detect one or more communication links that allow the node to communicate with other nodes, and a processor configured to determine that a universal overlay network is accessible using at least one communication link, select a selected communication link from the at least one communication link, and join the universal overlay network using the selected communication link.

In an aspect, an apparatus is provided for discovering peer-to-peer overlay networks. The apparatus comprises means for detecting one or more communication links that allow the node to communicate with other nodes, means for determining that a universal overlay network is accessible using at least one communication link, means for selecting a selected communication link from the at least one communication link, and means for joining the universal overlay network using the selected communication link.

In an aspect, a computer program product is provided for discovering peer-to-peer overlay networks. The computer program product comprises a computer-readable medium embodying codes executable by a processor to detect one or more communication links that allow the node to communicate with other nodes, determine that a universal overlay network is accessible using at least one communication link, select a selected communication link from the at least one communication link, and join the universal overlay network using the selected communication link.

Other aspects will become apparent after review of the hereinafter set forth Brief Description of the Drawings, Description, and the Claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects described herein will become more readily apparent by reference to the following Description when taken in conjunction with the accompanying drawings wherein:

FIG. **1** shows a network that comprises an exemplary universal discovery system;

FIG. **2** shows exemplary discovery apparatus for use at a node in accordance with the universal discovery system;

FIG. **3** shows an exemplary advertisement for use in accordance with the universal discovery system;

FIG. **4** shows an exemplary overlay database for use in accordance with the universal discovery system;

FIG. **5** shows an exemplary method for operating a discovery apparatus at a node in accordance with the universal discovery system;

FIG. **6** shows an exemplary method for operating a discovery apparatus at a node in accordance with the universal discovery system;

FIG. **7** shows an exemplary method for operating a discovery apparatus at a node in accordance with the universal discovery system;

FIG. **8** shows a diagram illustrating exemplary operation of the universal discovery system;

FIG. **9** shows an exemplary method for operating a discovery apparatus at a node in accordance with the universal discovery system; and

FIG. **10** shows exemplary discovery apparatus for use at a node in accordance with the universal discovery system.

## DESCRIPTION

The following description describes aspects of a universal discovery system that operates to facilitate creation, advertisement, and discovery of peer-to-peer overlay networks.

FIG. **1** shows a network **100** that comprises an exemplary universal discovery system. The network **100** comprises an underlying network **102** which in one implementation comprises an Internet Protocol network. Although the underlying network **102** is shown as a single entity, the underlying network may comprises any number and/or types of networks such as WANs, LANs, wireless networks or any other type of network.

In accordance with aspects of the universal discovery system, a discovery apparatus (DA) is provided for use at all or any of the nodes shown in FIG. **1**. For example, the DA is shown at selected nodes of the network **100** and operates to provide the functions of the universal discovery system described herein.

Connected Universal Overlay Network

The underlying network **102** comprises a "connected universal overlay network" **104**. The connected universal overlay network **104** is defined as a single universal overlay network created by Internet connected devices. The connected universal overlay network **104** comprises a subset of nodes of the underlying network **102** that are assigned corresponding overlay node identifiers. For example, the connected universal overlay network initially comprises nodes **50**, **60**, **80**, and **95**. The nodes communicate with each other utilizing the services of the underlying network **102**. For example, the nodes of the connected universal overlay network **104** are connected by communication links provided by the underlying network **102** to form desired routing paths. It should also be noted that the connected universal overlay network **104** may have any topology or architecture to enable any routing configuration and is not limited to the configuration shown in FIG. **1**.

Disconnected Universal Overlay Network

The network **100** also comprises a "disconnected universal overlay network" **106**. The disconnected universal overlay network **106** is defined as a single universal overlay network created by non-Internet connected devices. For example, the disconnected universal overlay network initially comprises nodes **4**, **6**, **8**, and **10**. The nodes of the disconnected universal overlay network **106** communicate with each other without utilizing the services of an underlying network. For example, the nodes utilize any suitable transmission technology (such as WiFi technology) to communication with each other. The nodes form the disconnected overlay network **106** when one node initially advertises the disconnected overlay network **106** and each of the other nodes progressively joins. It should be noted that the disconnected universal overlay network **106** is not limited to utilizing WiFi technology and may utilize any other type of communication technology. Furthermore, the universal discovery system is suitable for use with any number and/or types of disconnected overlay networks. It should also be noted that the disconnected universal overlay network **106** may have any topology or architecture to enable any routing configuration and is not limited to the configuration shown in FIG. **1**.

Discovery Apparatus

The DA operates at a node to provide the following functions in accordance with the universal discovery system described herein.

1. Maintain a database of overlay networks associated with communication interfaces available at a particular node.
2. Determine available communication links at power-on or any time during operation.
3. Select overlay networks to join based on available communication links.
4. Join a connected universal overlay network if possible.
5. Join a disconnected universal overlay network if possible.
6. After joining a universal connected or disconnected overlay networks, advertise, and discover any overlay networks such that bootstrap peers are accessed using UNLs.

Exemplary Operation

During operation of the universal discovery system, each node attempts to become part of one or more overlay networks based on communication mediums (or "links") available to the node. For example, a node comprises one or more communication interfaces that allow communication over corresponding communication links. For example, the communication interfaces comprise Ethernet, WiFi, Bluetooth, and/or any other type of interface that can be used to communicate with other nodes. Each node is configured with or otherwise obtains information identifying overlay networks that are associated with one or more of its communication interfaces.

The DA operates to determine whether there is an available communication link associated with each interface. For example, a node may have a WiFi interface but may not be within range of any other WiFi enabled nodes with which to establish a WiFi communication link. Once the DA determines the available communication links, it searches its database to identify overlay networks associated with each link. The DA then attempts to join the identified overlay networks associated with each link. For example, if a node has access to the Internet on a particular communication link, it attempts to join the connected universal overlay network. If a node does

not have Internet connectivity, it can still join overlays on other interfaces that have been enabled for overlay operation, such as the WiFi, Bluetooth or other interfaces. The disconnected universal overlay network **106** is an example of nodes that have formed a disconnected overlay network based on an available WiFi communication links. Nodes may choose to join multiple overlays via multiple interfaces as per policy information associated with each node.

Joining the Connected Universal Overlay

Referring again to FIG. **1**, node **108** is located on the underlying network **102** and the DA located at node **108** determines that a communication link is available to allow it to join the connected universal overlay network **104**. For example, the node may include a wireless wide area network (WWAN) interface that is able to communicate on the underlying network **102**. In one implementation of the universal discovery system, if a node has Internet connectivity it always attempts to join the connected universal overlay network. Thus, the DA at node **108** determines that a WWAN communication link is available and uses this link to join the connected universal overlay network **104** and is assigned node identifier **70**.

Once connected to the connected universal overlay network **104**, the node **108** operates to advertise or join other connected overlays. For example, the node **108** joins the connected overlay **110**, which also comprises nodes **50** and **80**. For example, the connected overlay **110** may be an overlay wherein participants can obtain sports clips or other sports related content.

Joining the Disconnected Universal Overlay

Referring again to FIG. **1**, node **112** is not located on the underlying network **102** and the DA located at node **112** determines that a communication link is available to allow it to join the disconnected universal overlay network **106**. For example, the node may include a WiFi interface that is able to communicate with other nodes on the disconnected universal overlay network **106**. In one implementation of the universal discovery system, a node always attempts to join the disconnected universal overlay network. Thus, the DA at node **108** determines that a WiFi communication link is available and uses this link to join the disconnected universal overlay network **106** and is assigned node identifier **2**.

Once joined to the disconnected universal overlay network **106**, the node **112** operates to advertise or join other disconnected overlays. For example, the node **112** joins the disconnected overlay **114**, which also comprises nodes **4** and **6**. For example, the disconnected overlay **114** may be a photo-sharing overlay wherein participants can participate in photo sharing.

Advertising Disconnected Overlays

To illustrate this aspect of the universal discovery system, it will be assumed that the DA at node **112** determines that a link exists whereby the node **112** can join the connected universal overlay network **104**. For example, the node **112** comprises a WWAN interface and a WWAN link is detected to allow the node **112** to communicate with the underlying network **102**. In doing so, the node **112** discovers the connected universal overlay network **104**, and as a result of joining, is assigned overlay identifier **40**, as illustrated in FIG. **1**.

Once connected to the connected universal overlay network **104**, the node **112** operates to advertise the disconnected universal overlay network **106** on the connected universal overlay network **104**. For example, the node **112** publishes an advertisement (Ad) at node **95** that identifies the disconnected overlay network **106** and indicates that a node **40** can be used to reach the disconnected universal overlay network **106**. For example, node **40** is identified in the Ad by a universal node locator relative to the connected overlay network **104**. Other nodes on the connected universal overlay network **104** can then discover the Ad and reach the disconnected universal overlay network **106** through node **112** (identified as **40**).

This advertisement mechanism can result in the formation of other application-specific overlay networks. Furthermore, this mechanism applies to both disconnected and connected universal overlays. It should also be noted that the node **112** may also advertise the disconnected overlay network **114** on the connected universal overlay **104**. Thus, any of the nodes located on the connected universal overlay **104** may join and participate with the disconnected overlay network **114** by using the node identified as **40** on the connected universal overlay **104**.

Node Mobility

The universal discovery system allows nodes to remain connected to each other during node mobility. For example, node **116**, which has node identifier **4** on the disconnected universal overlay network **106**, leaves the disconnected universal overlay network **106**, as shown at **118**. For instance, node **116** is a mobile phone that is changing its geographic location. The node **116** can query the connected universal overlay network **104** either by joining the overlay, or as a client. For this description, it will be assumed that the node **116** comprises an interface that provides a communication link to the underlying network **102**, and therefore allows the node **116** to join the connected universal overlay network **104**, and is assigned node identifier **90**. The node **116** is then able to discover (shown at **120**) the Ad at node **95** published by the node **112**. The Ad identifies UNL **40** (node **112**) on the connected universal overlay network **104** that can be used to bootstrap back into the disconnected overlay network **106**, as illustrated by paths **122** and **124**. Thus, the node **116**, which left the disconnected overlay network **106**, is able to communicate with nodes of the disconnected overlay network **106** through the use of the connected universal overlay network **104**. As a result, the node **116** may still communicate on the photo-sharing overlay **114**.

Universal Node Locators

As described above, the universal discovery system facilitates a common medium over which nodes can perform overlay advertisements or discover overlay networks and then join them. In this context, the system provides a mechanism where bootstrap nodes are named in the context of the universal overlay network. This removes the deployment consideration and difficulty with determining whether a bootstrap node is publicly reachable or not when advertising an overlay.

Thus, the universal discovery system provides that the overlay configuration document contains universal node locators instead of IP addresses and port numbers for specifying bootstrap peers. Consider an example of the photo-sharing overlay **114** advertised on the connected universal overlay network **104** at node identifier **95**. In the overlay configuration document of the photo-sharing overlay, a bootstrap peer element may contain an entry of the form;

overlay-node://40/;context="universal overlay disc"

This specifies that the bootstrap peer is reachable via a disconnected universal overlay. Any node can then connect to the node identifier **40** on the connected universal overlay network **104** to then be bootstrapped to the photo-sharing disconnected overlay **114**.

Therefore, the system provides a mechanism for advertising and discovery of overlays in any scenario of nodes either being connected to the Internet or even when they are in disconnected mode. It allows an overlay to be discovered and reformed across disjoint subnets (e.g. mobility of a node from

a closed home network to the mobile internet) by creating a common medium for reachability of overlays. A more detailed description of the operation of the DA and the universal discovery system is provided below.

FIG. **2** shows exemplary discovery apparatus **200** for use at a node in accordance with the universal discovery system. For example, the DA **200** is suitable for use as the DA shown in FIG. **1**. The DA **200** comprises processor **202**, memory **204**, and transceiver **206** all coupled to communicate on a data bus **208**. It should be noted that the DA **200** is just one implementation and that other implementations are possible.

The transceiver **206** comprises hardware and/or hardware executing software that operates to allow the DA **200** to communicate data or other information with other nodes using a variety of communication interfaces. For example, the transceiver **206** comprises Bluetooth **214**, WiFi **216**, and WWAN **218** interfaces that can be used to establish communication links with nodes on a connected universal overlay network or with nodes on disconnected overlay networks. Although three communication interfaces are shown, the transceiver **206** can comprises any number and/or types of communication interfaces.

The memory **204** comprises any suitable storage device operable to store an overlay database **210**, universal discovery module **212**, advertisements (ADs) **220**, and overlay (OL) routing module **222**. The overlay database **210** comprises information (i.e., meta-data) associated with one or more overlay networks. For example, the overlay database **210** identifies connected universal overlay networks and/or disconnected overlay networks that the DA **200** should attempt to join based on the accessible communication links.

The universal discovery module **212** comprises one or more modules comprising instructions or codes executable by the processor **202** to provide the functions of the universal discovery system described herein.

The ADs **220** comprises information to be published on an overlay network identifying peers that provide access to one or more overlay networks. The ADs **220** comprise UNLs that identify nodes relative to universal overlay networks that can be used to reach the advertised networks.

The overlay routing module **224** comprises one or more modules comprising instructions or codes executable by the processor **202** to control how to route packets, maintain state, make repairs, and/or other functions associated with a particular overlay network.

The processor **202** comprises at least one of a CPU, processor, gate array, hardware logic, memory elements, and/or hardware executing software. In an aspect, the processor **202** operates to execute instructions of the universal discovery module **212** to control the DA **200** to perform the functions of the universal discovery system described herein. In another implementation, all of the functions of the DA **200** are implemented by one or more integrated circuits.

Overlay Network Database

During operation, the processor **202** operates to obtain the overlay database **210** that comprises information about overlay networks. For example, during node configuration, the overlay database **210** is downloaded to the DA **200** using an available interface of the transceiver **206** and stored in the memory **204** by the processor **202**. During operation, the overlay database **210** is updated as the processor **202** becomes aware of information and/or meta-data associated with one or more overlay networks. In one implementation, the processor **202** receives user input that indicates the overlay networks to be associated with each interface. The processor **202** operates to store this information and/or meta-data in the overlay database **210**. For example, the information in the overlay database **210** comprises, but is not limited to the following information.

1. Overlay network names
2. Node addresses
3. Introducer node addresses
4. Content types
5. Specific content
6. Quality of service (QoS) parameters
7. Overlay network operating region
8. Overlay network type

Joining Overlay Networks

The processor **202** operates to control the transceiver logic **206** to detect available communication links. For example, the transceiver logic **206** operates to determine available communication links using its communication interfaces (**214**, **216**, **218**). Based on the available communication links, the processor **202** operates to select overlay networks from the database **210** in which to participate. For example, if a WWAN communication link is detected, the processor **202** selects an overlay network from the overlay database **210** that is associated with WWAN communication link. Such a selection may be a connected universal overlay network, or a disconnected overlay network. The processor **202** then controls the transceiver **206** to join the selected overlay network.

Advertising Overlay Networks

Once a node joins a universal overlay network, the DA **200** generates and advertises other overlay networks to which the node can provide access. The advertisements include a UNL that identifies the node relative to the universal overlay network. For example, the processor **202** operates to generate advertisements associated with disconnected overlay networks and store these advertisements in the memory **204** as ADs **220**. When the connected universal overlay network is joined, the processor **202** determines which disconnected overlay networks are accessible by the communication links of the transceiver **206**. The processor **202** then selects the appropriate advertisement and controls the transceiver **206** to publish these advertisements on the connected universal overlay network. Therefore, any node on the connected universal overlay network may search for and discover the advertisements and obtain access to the disconnected overlay networks through the identified node by using the UNL included in the advertisement.

In an aspect, the universal discovery system comprises a computer program product having one or more program instructions ("instructions") or sets of codes ("codes") stored or embodied on a machine-readable medium. When the codes are executed by at least one processor, for instance, the processor **202**, their execution causes the DA **200** to provide the functions of the universal discovery system described herein. For example, the machine-readable medium comprises a floppy disk, CDROM, memory card, FLASH memory device, RAM, ROM, or any other type of memory device or machine-readable medium that interfaces to the DA **200**. In another aspect, the sets of codes may be downloaded into the DA **200** from an external device or communication network resource. The sets of codes, when executed, operate to provide the functions of a universal discovery system as described herein.

FIG. **3** shows an exemplary advertisement **300** for use in accordance with the universal discovery system. For example, the advertisement **300** may be the Ad at node **95** shown in FIG. **1**. The advertisement **300** comprises an overlay name **302**, connection parameters **304**, UNL **306**, and security certificate **308**. The UNL **306** identifies a node on a universal overlay network that provides access to the adver-

tised overlay network. It should be noted that the advertisement **300** may comprise more parameters if needed to identify the advertised network or control access to it.

FIG. **4** shows an exemplary overlay database **400** for use in accordance with the universal discovery system. For example, the overlay database **400** may be the overlay database **210** shown in FIG. **2**.

The overlay database **400** comprises interface types **402**, network identifiers **404** and status **406**. The interface types **402** identify the types of interfaces that may become available to a node during operation. For example, the interface types include WWAN, WiFi, and Bluetooth.

The network identifiers **404** identify networks to be joined for each interface type. For example, the network identifiers comprise universal connected and disconnected overlay networks, and a variety of other networks such as sports clips, photo share and music share networks. In one implementation the network identifiers are listed in priority so that if the corresponding interface type is available, the system operates to join the network identifier having the highest priority first. In some cases, it is possible to join multiple networks using the same interface type. For example, the WWAN interface type may be used to join the connected universal overlay network and a sports clip overlay network.

The status **406** identifies the current status of each identified network **404**. For example, the universal connected overlay network on the WWAN interface is shown at joined.

FIG. **5** shows an exemplary method **500** for operating a discovery apparatus at a node in accordance with the universal discovery system. For clarity, the method **500** is described below with reference to the DA **200** shown in FIG. **2**. In one implementation, the processor **202** executes one or more sets of codes provided by the discovery module **212** to control the DA **200** to perform the functions described below.

At block **502**, information from an overlay database is obtained. The overlay database comprises information identifying overlay networks and associated communication interfaces that are to be used to participate on those networks. For example, the overlay database is formatted as the overlay database **400** shown in FIG. **4** and stored in the memory **204** as overlay database **210**. In an aspect, information for the overlay database **210** is provided to the DA **200** during node configuration, downloaded to the DA **200** during operation, and/or updated with user input. The processor **202** operates to update, modify, and/or otherwise maintain the overlay database **210** as more overlay networks are detected or become available. In one implementation, information from the overlay database **210** is retrieve from the memory **204** by the processor **202**.

At block **504**, available communication links are detected. For example, the processor **202** controls the transceiver logic **206** to detect available communication links associated with one or more communication interfaces. The communication interfaces comprises WWAN, WiFi, Bluetooth, or any other suitable communication interface.

At block **506**, a determination is made as to whether a connected universal overlay network is accessible given the detected communication links. In one implementation, the processor **202** makes this determination by controlling the transceiver **206** to determine if a connected universal overlay network is accessible on any of available interfaces. If the connected universal overlay is accessible on one or more interfaces, the method proceeds to block **508**. If the connected universal overlay in not accessible, the method proceeds to block **512**.

At block **508**, an interface is selected that is to be used to join the connected universal overlay network. In one implementation, the processor **202** accesses the overlay database **210** to cross-reference the detected interfaces to determine which interface to use to connect to the connected universal overlay network. If the connected universal overlay is available on multiple interfaces, the processor **202** selects the interface to use based on signal strength, frequency, data rate, throughput, or any other parameter or criteria. Therefore, a low data rate connection to the connected universal overlay network may be replaced with a high data rate connection, if such a connection is available.

At block **510**, the connected universal overlay network is joined. For example, the processor **202** controls the transceiver **206** to join the connected universal overlay network using the interface and communication link selected at block **508**. After joining the processor **202** updates the status **406** in the database **210**.

At block **512**, a determination is made as to whether a disconnected overlay network is accessible given the detected communication links. In one implementation, the processor **202** makes this determination by controlling the transceiver **206** to determine if a disconnected universal overlay network is accessible on any of available interfaces. If the disconnected universal overlay is accessible on one or more interfaces, the method proceeds to block **514**. If the disconnected universal overlay in not accessible, the method proceeds to block **518**.

At block **514**, an interface is selected that is to be used to join the disconnected universal overlay network. In one implementation, the processor **202** accesses the overlay database **210** to cross-reference the detected interfaces to determine which interface to use to connect to the disconnected universal overlay network. If the disconnected universal overlay is available on multiple interfaces, the processor **202** selects the interface to use based on signal strength, frequency, data rate, throughput, or any other parameter or criteria. Therefore, a low data rate connection to the disconnected universal overlay network may be replaced with a high data rate connection, if such a connection is available.

At block **516**, the disconnected universal overlay network is joined. For example, the processor **202** controls the transceiver **206** to join the disconnected universal overlay network using the appropriate interface and communication link determined at block **514**. After joining the disconnected overlay network, the processor **202** updates the status **406** in the database **210**.

At block **518**, a determination is made as to whether any other overlay networks are accessible given the detected communication links. In one implementation, the processor **202** makes this determination by controlling the transceiver **206** to determine if any other overlay network is accessible on any of available interfaces. If any other overlay network is accessible on one or more interfaces, the method proceeds to block **520**. If no other overlay network is accessible, the method ends.

At block **520**, interfaces are selected that is to be used to join one or more other overlay networks. In one implementation, the processor **202** accesses the overlay database **210** to cross-reference the detected interfaces to determine which interface to use to connect to the other overlay networks. If the other overlays are available on multiple interfaces, the processor **202** selects the interfaces to use based on signal strength, frequency, data rate, throughput, or any other parameter or criteria. Therefore, a low data rate connection to a particular overlay network may be replaced with a high data rate connection, if such a connection is available.

At block **522**, the other overlay networks are joined. For example, the processor **202** controls the transceiver **206** to join the other overlay networks using the appropriate inter-

faces and communication links determined at block **520**. After joining the other overlay networks, processor **202** updates the status **406** in the database **210**.

Therefore, the method **500** operates to provide a fast and efficient system for the discovery and joining of overlay networks. The method **500** is performed by a discovery apparatus at a node in accordance with the universal discovery system. It should be noted that the method **500** is just one implementation and that the operations of the method **500** may be rearranged or otherwise modified within the scope of the various aspects. Thus, other implementations are possible.

FIG. **6** shows an exemplary method **600** for operating a discovery apparatus at a node in accordance with the universal discovery system. For clarity, the method **600** is described below with reference to the DA **200** shown in FIG. **2**. In one implementation, the processor **202** executes one or more sets of codes provided by the discovery module **212** to control the DA **200** to perform the functions described below.

At block **602**, a node identity is established on a connected universal network. For example, the processor **202** determines that a connected universal overlay network is accessible through an existing communication interface. The processor **202** then operates to control the transceiver **206** to join the connected universal overlay network using the appropriate communication interface and obtain a node identifier on the connected universal overlay network.

At block **604**, advertisements for one or more overlay networks are generated. In an aspect, the processor **202** generates one or more advertisements that advertise one or more overlay networks to which the node currently has access. The advertisements are stored in the memory as part of the ADs **220**. In an aspect, the advertisements are formatted as shown in FIG. **3**. The advertisements comprise UNLs to identify nodes on a connected or disconnected universal overlay network that provide access to the advertised overlays.

At block **606**, the generated advertisement(s) is published on a universal overlay network. In an aspect, the processor logic **202** controls the transceiver **206** to publish the advertisement on either a connected or disconnected universal overlay network.

At block **608**, a request is received to access an advertised overlay network. For example, a second node having access to the universal overlay network discovers the advertisement and determines that a selected overlay network can be reached through the current node identified by the UNL in the advertisement. The second node sends a request to join the selected overlay network to the current node using the connected universal overlay network.

At block **610**, the received join request is routed to the closest node in the identification space associated with the overlay network. The processor **202** receives the request and routes the request to the appropriate node on the advertised overlay network using the transceiver **206**.

Therefore, the method **600** operates to provide a fast and efficient mechanism for advertising access to one or more overlay networks. The method **600** is performed by discovery apparatus **200** operating at a node in accordance with the universal discovery system. It should be noted that the method **600** is just one implementation and that the operations of the method **600** may be rearranged or otherwise modified within the scope of the various aspects. Thus, other implementations of the method **600** are possible.

FIG. **7** shows an exemplary method **700** for operating a discovery apparatus at a node in accordance with the universal discovery system. For clarity, the method **700** is described below with reference to the discovery apparatus **200** shown in FIG. **2**. In one implementation, the processor **202** executes one or more sets of codes provided by the discovery module **212** to control the discovery apparatus **200** to perform the functions described below.

At block **702**, communication with a first overlay network is terminated. For example, the node may be a mobile phone that is leaving its current geographic area and as a result, terminates a connection to a first overlay network. In an aspect, the processor **202** controls the transceiver **206** to terminate the network connection. The first overlay network may be a disconnected overlay network. The processor **202** also updates the status **406** in the database **210**.

At block **704**, available communication links are detected. In an aspect, the processor **202** controls the transceiver **206** to detect available communication links associates with one or more communication interfaces.

At block **706**, a determination is made as to whether a connected universal overlay network is accessible. For example, the processor **202** determines if access to a connected universal overlay network is available based on the detected communication links. If the connected universal overlay network is accessible, the method proceeds to block **708**. If the connected universal overlay network is not accessible, the method returns to block **704**.

At block **708**, a connected universal overlay network is joined. In an aspect, the processor **202** controls the transceiver **206** to join the connected universal overlay network using the appropriate communication interface and corresponding communication link. The processor **202** also updates the status **406** in the database **210**.

At block **710**, an advertisement for the first overlay network is discovered on the connected universal overlay network. In an aspect, the processor **202** controls the transceiver **206** to search the connected universal overlay network to discover the advertisement. For example, the advertisement is formatted as the advertisement **300** shown in FIG. **3**.

At block **712**, a bootstrap peer on the connected overlay network is determined that can provide access to the first overlay network. In an aspect, the processor **202** processes the advertisement to determine a bootstrap peer that can be used to reach the first overlay network. For example, the peer is identified on the universal overlay network by a UNL included in the advertisement.

At block **714**, traffic is routed to the first overlay network using the bootstrap peer on the connected universal overlay network. In an aspect, the processor **202** controls the transceiver **206** to route traffic for the first overlay network using the peer.

Therefore, the method **700** allows a device to maintain communication with an overlay network during device mobility. The method **700** is performed by discovery apparatus **200** operating at a node in accordance with the universal discovery system. It should be noted that the method **700** is just one implementation and that the operations of the method **700** may be rearranged or otherwise modified within the scope of the various aspects. Thus, other implementations of the method **700** are possible.

FIG. **8** shows a diagram **800** illustrating exemplary operation of the universal discovery system. For example, the diagram **800** illustrates how a DA located at a node operates to advertise and form a disconnected universal overlay network.

The node **802** comprises a discovery apparatus that operates in accordance with the discovery system. The DA detects the available communication interfaces and selects a Bluetooth (BT) interface to advertise a disconnected universal overlay network to other nodes in the region **804**. The nodes **806** and **808** communicate with the node **802** in response to

the advertisement to form the disconnected overlay network **810**. The nodes **802**, **806**, and **808** join the disconnected universal overlay network **810** based on information in their respective overlay databases.

FIG. **9** shows an exemplary method **900** for operating a discovery apparatus at a node in accordance with the universal discovery system. The method **900** is suitable for use at blocks **706** and **708** of the method **700**. For clarity, the method **900** is described below with reference to the discovery apparatus **200** shown in FIG. **2**. In one implementation, the processor **202** executes one or more sets of codes provided by the discovery module **212** to control the discovery apparatus **200** to perform the functions described below.

At block **902**, a determination is made as to whether a connected universal overlay network is accessible on multiple communication links. For example, the processor **202** determines if access to a connected universal overlay network is available based on the detected communication links. If the connected universal overlay network is accessible on multiple communication links, the method proceeds to block **904**. If the connected universal overlay network is accessible on a single communication link, the method proceeds to block **908**.

At block **904**, a link with which to join the connected universal overlay network is selected based on selection criteria. The processor **202** makes this selection. The selection criteria include but are not limited to frequency, bandwidth, data rate, throughput, and/or any other type of selection criteria. Thus, a high data rate link may be chosen over a low data rate link.

At block **906**, any connection to the connected universal overlay network based on any unselected link is terminated. The processor **202** controls the transceiver **206** to perform this function.

At block **912**, the selected link is used to join the connection universal overlay network. The processor **202** controls the transceiver **206** to join the connected universal overlay network using the selected link.

Therefore, the method **900** operates to select the best link available for connecting to the connected universal overlay. The method **900** is performed by discovery apparatus operating at a node in accordance with the universal discovery system. It should be noted that the method **900** is just one implementation and that the operations of the method **900** may be rearranged or otherwise modified within the scope of the various aspects. Thus, other implementations of the method **900** are possible.

FIG. **10** shows exemplary discovery apparatus **1000** for use at a node in accordance with the universal discovery system. For example, the DA **1000** is suitable for use as the DA shown in FIG. **1**. In an aspect, the DA **1000** is implemented by at least one integrated circuit comprising one or more modules configured to provide aspects of the universal discovery system as described herein. For example, each module comprises hardware and/or hardware executing software.

The DA **1000** comprises a first module comprising means (**1002**) for detecting one or more communication links that allow a node to communicate with other nodes, which in an aspect comprises the transceiver **206**. The DA **1000** also comprises a second module comprising means (**1004**) for determining that a universal overlay network is accessible using at least one communication link, which in an aspect comprises the processor **202**. The DA **1000** also comprises a third module comprising means (**1006**) for selecting a selected communication link from the at least one communication link, which in an aspect comprises the processor **202**. The DA **1000** also comprises a fourth module comprising means (**1008**) for joining the universal overlay network using the selected communication link, which in an aspect comprises the processor **202**.

The various illustrative logics, logical blocks, modules, and circuits described in connection with the aspects disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but, in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

The steps of a method or algorithm described in connection with the aspects disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor, such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a wireless communication device. In the alternative, the processor and the storage medium may reside as discrete components in a wireless communication device.

The description of the disclosed aspects is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these aspects may be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects, e.g., in an instant messaging service or any general wireless data communication applications, without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the aspects shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein. The word "exemplary" is used exclusively herein to mean "serving as an example, instance, or illustration." Any aspect described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects.

Accordingly, while aspects of a universal discovery system have been illustrated and described herein, it will be appreciated that various changes can be made to the aspects without departing from their spirit or essential characteristics. Therefore, the disclosures and descriptions herein are intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the following claims.

What is claimed is:

**1**. A method for operating a node to discover a peer-to-peer overlay network, the method comprising:

detecting, via a transceiver controlled by a processor of the node, one or more communication links that allow the node to communicate with other nodes;

determining that a universal overlay network is accessible using at least one communication link;

selecting the at least one communication link;

joining the universal overlay network using the selected communication link; and

generating, by the processor, a first advertisement that provides a first identifier that identifies the node on the universal overlay network as a bootstrap node for reaching a selected overlay network, wherein the first identifier is a universal node locator (UNL) relative to the universal overlay network.

**2**. The method of claim **1**, wherein said determining comprises determining whether the universal overlay network is accessible based on information identifying overlay networks associated with each link.

**3**. The method of claim **2**, wherein said determining whether the universal overlay network is accessible comprises retrieving the information from an overlay database.

**4**. The method of claim **3**, wherein the overlay database comprises information for identifying a plurality of prioritized networks to be joined for each communication link type.

**5**. The method of claim **1**, further comprising publishing the first advertisement on the universal overlay network.

**6**. The method of claim **1**, further comprising obtaining a second advertisement from the universal overlay network that provides a second identifier that identifies a second node on the universal overlay that is used as a second bootstrap node for reaching a second selected overlay network.

**7**. The method of claim **6**, wherein the second identifier is a second universal node locator (UNL).

**8**. The method of claim **7**, further comprising communicating with the second selected overlay network utilizing the second UNL.

**9**. The method of claim **1**, wherein the universal overlay network is one of a connected or disconnected universal overlay network.

**10**. The method of claim **1**, wherein the selected overlay network is different from the universal overlay network, and wherein the UNL is different from an Internet Protocol (IP) address and a port number and allows an overlay to be discovered and reformed across disjoint subnets.

**11**. An apparatus of a network node for discovering peer-to-peer overlay networks, the apparatus comprising:

a transceiver configured to detect one or more communication links that allow the network node to communicate with other network nodes; and

a processor configured to:

determine that a universal overlay network is accessible using at least one communication link;

select the at least one communication link;

join the universal overlay network using the selected communication link; and

generate a first advertisement that provides a first identifier that identifies the network node on the universal overlay network as a bootstrap node for reaching a selected overlay network, wherein the first identifier is a universal node locator (UNL) relative to the universal overlay network.

**12**. The apparatus of claim **11**, wherein said processor is configured to determine whether the universal overlay network is accessible based on information identifying overlay networks associated with each link.

**13**. The apparatus of claim **12**, wherein said processor is configured to retrieve the information from an overlay database.

**14**. The apparatus of claim **13**, wherein the overlay database comprises information for identifying a plurality of prioritized networks to be joined for each communication link type.

**15**. The apparatus of claim **11**, wherein said processor is configured to publish the first advertisement on the universal overlay network.

**16**. The apparatus of claim **11**, wherein said processor is configured to obtain a second advertisement from the universal overlay network that provides a second identifier that identifies a second node on the universal overlay that is used as a second bootstrap node for reaching a second selected overlay network.

**17**. The apparatus of claim **16**, wherein the second identifier is a second universal node locator (UNL).

**18**. The apparatus of claim **17**, wherein said processor is configured to communicate with the second selected overlay network utilizing the second UNL.

**19**. The apparatus of claim **11**, wherein the universal overlay network is one of a connected or disconnected universal overlay network.

**20**. The apparatus of claim **11**, wherein the selected overlay network is different from the universal overlay network, and wherein the UNL is different from an Internet Protocol (IP) address and a port number and allows an overlay to be discovered and reformed across disjoint subnets.

**21**. An apparatus of a network node for discovering peer-to-peer overlay networks, the apparatus comprising:

means for detecting one or more communication links that allow the network node to communicate with other network nodes;

means for determining that a universal overlay network is accessible using at least one communication link;

means for selecting the at least one communication link;

means for joining the universal overlay network using the selected communication link; and

means for generating a first advertisement that provides a first identifier that identifies the network node on the universal overlay network as a bootstrap node for reaching a selected overlay network, wherein the first identifier is a universal node locator (UNL) relative to the universal overlay network.

**22**. The apparatus of claim **21**, wherein said means for determining comprises means for determining whether the universal overlay network is accessible based on information identifying overlay networks associated with each link.

**23**. The apparatus of claim **22**, wherein said means for determining whether the universal overlay network is accessible comprises means for retrieving the information from an overlay database.

**24**. The apparatus of claim **21**, further comprising means for publishing the first advertisement on the universal overlay network.

**25**. The apparatus of claim **21**, further comprising means for obtaining a second advertisement from the universal overlay network that provides a second identifier that identifies a second node on the universal overlay that is used as a second bootstrap node for reaching a second selected overlay network.

**26**. The apparatus of claim **25**, wherein the second identifier is a second universal node locator (UNL).

**27**. The apparatus of claim **26**, further comprising means for communicating with the second selected overlay network utilizing the second UNL.

**28**. The apparatus of claim **21**, wherein the universal overlay network is one of a connected or disconnected universal overlay network.

**29**. A non-transitory computer-readable medium for discovering peer-to-peer overlay networks, the computer-readable medium embodying codes executable by a processor of a network node to:

detect one or more communication links that allow the network node to communicate with other network nodes;

determine that a universal overlay network is accessible using at least one communication link;

select the at least one communication link;

join the universal overlay network using the selected communication link; and

generate a first advertisement that provides a first identifier that identifies the network node on the universal overlay network as a bootstrap node for reaching a selected overlay network, wherein the first identifier is a universal node locator (UNL) relative to the universal overlay network.

**30**. The computer-readable medium of claim **29**, wherein said codes are configured to cause the processor to determine whether the universal overlay network is accessible based on information identifying overlay networks associated with each link.

**31**. The computer-readable medium of claim **30**, wherein said codes are configured to cause the processor to retrieve the information from an overlay database.

**32**. The computer-readable medium of claim **29**, wherein said codes are configured to cause the processor to publish the first advertisement on the universal overlay network.

**33**. The computer-readable medium of claim **29**, wherein said codes are configured to cause the processor to obtain a second advertisement from the universal overlay network that provides a second identifier that identifies a second node on the universal overlay that is used as a second bootstrap node for reaching a second selected overlay network.

**34**. The computer-readable medium of claim **33**, wherein the second identifier is a second universal node locator (UNL).

**35**. The computer-readable medium of claim **34**, wherein said codes are configured to cause the processor to communicate with the second selected overlay network utilizing the second UNL.

**36**. The computer-readable medium of claim **29**, wherein the universal overlay network is one of a connected or disconnected universal overlay network.

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